myth, miracle or marketing?

Horticultural oils

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In the late nineteenth century, mixtures of kerosene and soap were recommended for treating insect-infested crops. While quite effective in this regard, these early horticultural oils also caused collateral damage with their **phytotoxicity**; leaves in particular were heavily damaged. In the mid-1900s, refining technology improved to produce lighter petroleum-based oils with fewer impurities, thus reducing the damage to plants.

Today's horticultural oils include vegetable as well as mineral oil products. Recent studies have suggested that plant-based oils, such as soybean, are often just as effective as mineral oils and may be less phytotoxic. Regardless of their origin, horticultural oils are attractive alternatives to many conventional pesticides, as they are just as effective in controlling pests while simultaneously conserving nontarget organisms and decomposing quickly. Moreover, they can be used as adjuvants, or enhancers, for other alternative pesticides, including **Bt** *(Bacillus thuringiensis)* and **NPV** (nucleopolyhedrovirus) **insecticide**.

What are the differences?

The first commercially available products were **dormant** oils, or those meant for winter application while trees and shrubs are resting. These oils have a high distillation temperature, meaning they evaporate more slowly and stay on the plant longer than those with lower distillation temperatures.

Dormant oils are usually more viscous, enhancing their residency on sprayed surfaces. In contrast, summer oils, sometimes called **superior** oils, are lighter weight and more volatile than winter oils (i.e., have lower distillation temperatures). These summer oils have less residency time on sprayed plants, and they are also less likely to cause damage to leaves.

The distillation temperature is one of the two most important numbers on the label; the second is the UR designation, or percent unsulfonated residues in the product. Sulfonated residues contribute to the phytotoxicity of oils, so purer oils will have a higher percentage of unsulfonated residues and cause less foliar damage (discussed below): this number should be no lower than 92 percent.

It may take some trial and error to select the best oil for a particular pest on a given plant: insecticidal activity must be balanced with potential damage to the plant and other nontarget species. While the rate of evaporation is part of this balance, horticultural oils may also contain detergents or other proprietary additives, which improve application and enhance effectiveness of the product.

How do oils work?

Horticultural oil application immediately creates a physical barrier to respiration by clogging the **spiracles**, or breathing pores, along the sides of adult and larvae abdomens. Similarly, oils applied to egg masses inhibit oxygen uptake and decrease hatching success. Oxygen demands of all life stages decrease with decreasing temperature, however, so winter applications must be at a higher rate than those of summer oils to ensure sustained coverage.

Though contact mortality is considered to be the primary mode of action, horticultural oils also interact with cell membranes, interfering with their function and possibly creating toxins. Other research also points to a preventative role in deterring some insects from laying eggs, especially if plants are sprayed while females are actively seeking egg-laying territory. Furthermore, several studies have found horticultural oils to be feeding deterrents.

Horticultural oils are easy to apply and are relatively safe even for new growth, provided mixing and application directions are carefully followed.

Conflicting information is given regarding the residual effectiveness of horticultural oils. One research group reported that oil effectiveness lasted only 24 hours after application in the field, compared to two weeks postapplication in laboratory or greenhouse settings. However, oils are more quickly degraded and/or evaporated in the field than under more controlled conditions, so these differences in residual effectiveness are not surprising.

There are some conditions under which horticultural oils are not as effective. Wet leaves, or those washed by irrigation or rainfall too soon after application will not retain oils well. Likewise, oils sprayed onto plants with vertical leaves (including ornamental grasses) require a higher application rate and/or a greater viscosity, since the leaf angle enhances oil runoff. And don't waste time and resources using horticultural oils as soil drenches: they only succeed when they contact the targeted pest.

Are all insects controlled?

Unlike many gardening products that show promise in laboratory experiments but fail under real-world conditions, horticultural oils have been extensively tested in the lab, greenhouse, nursery, and field on a variety of insect pests found on many species of herbaceous and woody plants. Though not effective on all garden pests, horticultural oils can successfully combat common nuisances including aphids, scale, whiteflies (insects), and mites (arachnids). All are controlled by relatively low concentrations of oil (usually 1-2%) that generally are not phytotoxic. In comparison, slightly higher concentrations (3-5%) are needed for control of members of the orders Coleoptera, Heteroptera, and Lepidoptera. Still, these concentrations are usually not enough to cause leaf damage.

A handful of pests are apparently unaffected by horticultural oil application; for some insects, such as the Eastern tent caterpillar, researchers suspect that their dense hairs may prevent oils from reaching the spicules. Others, such as calico scale or adult beetles, have thick waxy plates or heavy carapaces that inhibit oil penetration. Though technically they do not induce genetic resistance, repeated use of horticultural oils can select for more resistant pest populations, such as scale insects with thicker, less permeable plates.

Choosing which horticultural oil to use is dependent on the life history of the targeted pest. If the insect overwinters on affected plants, then dormant oils can be used; likewise, species that arrive in the spring or summer should be treated with oils intended for application during the growing season. In any case, the pest population must be completely covered for the oil to be effective. This means spraying both sides of leaves, growing tips, or anywhere else control is needed.

Other plant problems

Given their effectiveness on many insect pests, horticultural oils could logically be used to decrease the transmission of insect-borne viruses, and in fact this property has been demonstrated in at least one study.

Several researchers have found widespread success in reducing the incidence of powdery mildew species on susceptible plants including apple, crapemyrtle, lilac, pepper, and rose. Antimicrobial activity against other disease organisms is more sporadic: for instance, one research group found oils to be ineffective against rose blackspot unless inoculum levels were quite low; yet another group reported success in controlling the same disease.

Mixed results have also been reported for treatment of fungi responsible for flyspeck and sooty blotch on apple and bacterial leaf spot on hydrangea and leaf blight on pepper. Still, researchers remain positive that use of horticultural oils and other biopesticides are effective alternatives to synthetics in suppressing foliar diseases.

What are the drawbacks?

Injury to plants

Early formulations of horticultural oils tended to contain impurities that caused damage to the foliage of many plant species. Modern formulations are highly purified and bear little resemblance to those first toxic mixtures of kerosene and other volatile chemicals, and professionals who routinely apply oils report little damage to plant material. Yet the fear of phytotoxicity lingers, so it's worth exploring the circumstances

under which plants might be damaged by horticultural oils.

While horticultural oils are intended to remain on leaf surfaces to have their pesticidal effects, they often end up inside the leaves as well. Using a variety of imaging techniques, researchers have been able to visualize movement of oils through the stomata and across the cuticle. Once inside, oils are able to move throughout treated leaves and into adjacent, untreated tissues. In some cases, this foliar uptake can result in phytotoxicity, manifesting itself as chlorotic or yellowing leaves, which might then develop brown stippling, necrotic leaf tips and margins, and/or a water-soaked appearance before eventually dying.

Happily, horticultural oils do not cause phytotoxicity to the vast majority of landscape trees and shrubs tested so far, including several "sensitive" species. Even herbaceous species in the greenhouse or landscape are relatively immune to damage. That being said, there are some species that react negatively to correctly applied horticultural oils:

- Junipers and spruces may lose their bluish bloom, as these foliar waxes are oil soluble
- Roses, though others refute this
- Grapevines may show reduced fruit set with repeated use of horticultural oils, though no foliar injury

In addition, phytoxicity can occur even in tolerant species when:

- Oils are applied at too high a rate
- Oil suspension is not constantly agitated, resulting in separation of oil and water
- Leaves are wilted at application time
- Humidity is too high, resulting in reduced oil evaporation

Most actively growing plants are not affected by horticultural oils, especially if they are not under environmental stress. The exception may be seedlings and other tender tissues, which can be injured by lengthy or repeated exposure to oil, though others have found no damage under similar conditions. Trees, shrubs, and vines that are actively used for fruit production may show a decrease in fruit quality parameters if leaves are repeatedly treated with oil; this is most likely due to the decreased photosynthetic ability of leaves with clogged stomata.

Dormant plants are even less likely to have a negative reaction to horticultural oils, tolerating up to four times the recommended spray application (8%) without damage. But it is important to ensure plants are completely dormant before applying winter oils, as they otherwise may be damaging.

Other factors that reportedly will lower the risk of oil phytoxicity include formulations with high percentages of UR (unsulfonated residues), UV radiation absorbers, or vegetable oils. High ambient temperatures apparently are not problematic as long as plants are well hydrated and relative humidity is low.

Paradoxically, phytotoxicity can be a desirable outcome, particularly when the pest in question is a weed. Horticultural oils can be used as carriers for fungal spores or other bioherbicides, and their ability to penetrate waxy leaf surfaces undoubtedly enhances the activity of the control agent.

What's the bottom line for using horticultural oils as pesticides?

DO

- Know the life history of a pest and choose the correct seasonal oil.
- Choose oils with the highest percent UR (unsulfonated residues).
- Follow label directions to the letter.
- Use the lowest possible concentration (e.g., 1-2% in summer; 3-4% in winter).
- Keep your oil mixture agitated at all times to prevent separation.
- Apply summer oils to plants with fully hydrated, but dry-surfaced leaves.
- Only apply oils when target pests are present.
- Be sure to cover the target insect completely; the oil will only work if the insect is completely enveloped.
- Be aware of beneficial insects and avoid spraying when they are actively feeding on pests.
- Test spray only a portion of a plant or groupings of plants if concerned about phytotoxicity.

DON'T

- Overuse oils. Like any other pesticide, natural or synthetic, overuse can damage nontarget species and ecosystems.
- Use oils on unregistered insects, arachnids, or diseases.
- Use unregistered vegetable or petroleum-based oils for pest control.
- Use oils as soil drenches.
- Mix with sulfur-containing pesticides. This effectively decreases the UR number and can cause phytotoxicity.
- Apply oils to wilted plants.
- Use oils on seedlings or other tender plant tissues.
- Use oils on conifers or other species with a waxy, bluish cast to their foliage.
- Apply when rain is expected, or when humidity is high (over 90% RH).
- Let oil drift onto water surfaces; it will inhibit oxygen transfer and possibly harm aquatic organisms.

Benefits to plants

Several studies have found additional, unexpected benefits of horticultural oil applications. Because they reduce gas exchange between treated tissues and the atmosphere, horticultural oils may delay bud break of dormant woody plants by increasing localized carbon dioxide levels. Such delay can protect leaf and flower buds from spring frost injury, though not all species tested have been equally affected by oil application. Application for this purpose may require higher concentrations of oil (8-10%), but no injury has been reported to emerging leaves and flowers once dormancy is broken.

Finally, oil application has been found to enhance the aroma of 'Golden Delicious' apples and may increase the diameter of oranges.

Injury to beneficial insects and arachnids

Reports of horticultural oil injury to beneficial insects and arachnids are a mixed bag. Some researchers have found high mortality of beneficial nematodes, predatory mites, and wasps, following oil applications. Others found no injury to predatory beetles, bugs, mites, wasps, or nontarget ground arthropods, including ants, beetles, and spiders. In one case, activity of nontarget ground beetles was actually enhanced by use of horticultural oil.

Understanding the lifestyle of predatory insects helps untangle this confusion. Unlike many pests who tend to remain on plant tissues for long periods of time, predators move from plant to plant in search of prey. If they are unfortunate enough to be on a plant at the time it's sprayed, they may suffer contact mortality just like the pest species. However, the likelihood that all predators in a local population are sitting on the same plant at the same time is small, and therefore, predator species are less likely to be eliminated in a landscape situation.

There is no doubt that beneficial arachnids and insects closely related to sensitive pest species may be injured by horticultural oils. Not only will they suffer from contact toxicity, but their prey will be less available after treatment, affecting their ability to survive and reproduce. (See sidebar on the do's and don'ts of using horticultural oils as pesticides.)

Horticultural oils are a viable alternative to many synthetic pesticides and can become part of any gardener's plant health-care program. They work as well as conventional pesticides, can be more effective and economic than predatory insects, and are safe for people, pets, and the environment. Moreover, the reduction in use of synthetic pesticides will enhance the natural diversity of insects, arachnids, and other beneficials in the landscape, increasing its health and sustainability. I consider horticultural oils to be a rational addition to an informed gardener's IPM toolbox.

References

A full listing of references are located on the author's Web site:
www.puyallup.wsu.edu/~Linda%20Chalker-Scott